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Emergency Response Procedures for Control of Hazardous Substance Releases

Rockwell International, Newbury Park, CA

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Municipal Environmental Research Lab.
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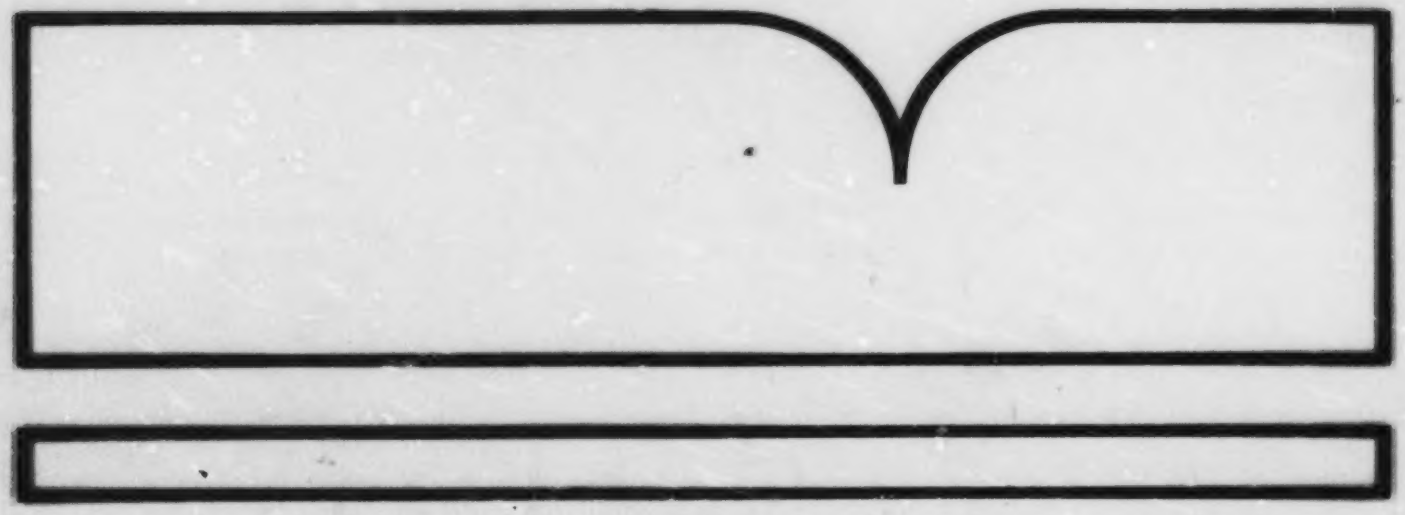

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EMERGENCY RESPONSE PROCEDURES FOR CONTROL OF HAZARDOUS SUBSTANCE RELEASES

by

Robert W. Melvold
Rockwell International
Newbury Park, CA 91320

Leo T. McCarthy, Jr.
Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Edison, NJ 08837

MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OH 45268

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16. ABSTRACT

Information is provided for selecting the best spill stabilization controls for hazardous substances regulated by the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). Guidance is provided for the initial response of the immediate removal phase (Phase III of the National Contingency Plan, Subpart F). Initial or emergency response is defined as the stabilization or control required in the early stages of a release to halt further impact of the released substance on the public and the environment. Spill stabilization methods are identified as feasible for use in initial response efforts. Information is also provided on the onsite assessment of spill severity, application of precautionary measures, determination of response effectiveness and termination of initial response. To adequately provide relevant guidance for almost 500 CERCLA chemicals covered in the study, a hazardous substance classification system was developed based on (1) a substance's chemical and physical properties, and (2) a substance's hazard potential to the public, to the workers, and to the environment. All substances that generally behave similarly upon release, based on their physical and chemical properties, are placed within a specific class. Additionally, substances (within a class) that exhibit similar hazards upon release are placed in the same subclass. Subclass-specific guidance is given in individual spill response charts that provide the user with information on associated personnel safety hazards and control options available for releases of chemicals from each subclass.

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Emergency Response Procedures for Control of Hazardous Substance Releases[1]

by

Robert W. Melvold
Environmental and Energy Systems Division
Rockwell International
Newbury Park, CA 91320

and

Leo T. McCarthy, Jr.
Oil and Hazardous Materials Spills Branch
Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Edison, NJ 08837

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To adequately provide relevant guidance for almost 500 CERCLA chemicals covered in the study, a hazardous substance classification system was developed based on (1) a substance's chemical and physical properties, and (2) a substance's hazard potential to the public, to the workers, and to the environment. All substances that generally behave similarly upon release, based on their physical and chemical properties, are placed within a specific class. Additionally, substances (within a class) that exhibit similar hazards upon release are placed in the same subclass. Subclass-specific guidance is given in individual spill response charts that provide the user with information on associated personnel safety hazards and control options available for releases of chemicals from each subclass.

INTRODUCTION

Action guides for response to hazardous substance spill incidents typically stress decision-making with specific reference to explosions, fire control, and personnel safety or the threat thereof. Environmental consequences are not usually factored into the decision-making process. This paper describes an approach to provide information to assist first-on-scene personnel, such as firefighters, in their decision-making processes at hazardous substances incidents, particularly those in which no explosion, fire, or severe safety threat is involved, but which nevertheless endanger the environment.

EVALUATION OF CONTROL METHODS

Approach

The candidate spill control methods were evaluated for their effectiveness in protecting life, property and the environment by stabilizing a chemical spill. The objective of the evaluation was to examine each method's ability to meet selected performance and practicality criteria.

Using this comparative approach, countermeasures that meet the criteria and are applicable for first response, excluding methods that are distinctly used for cleanup and disposal, were evaluated.

The evaluation does not rank the selected methods according to ultimate effectiveness because the overall superiority of a particular method is significantly influenced by site-specific conditions that vary. However, the degree of danger posed by the chemical itself is included in the evaluation, while site specific variables such as the volume and location of the spill, topography, and meteorological conditions are examined since they will ultimately determine the best method for a particular spill.

Matrices were developed to consider spilled substances in various physical and chemical states on land and in water. Because not all methods apply to both media and because certain methods are designed to control medium-specific behavior, the following four spill scenarios were used:

- o Substances on land.
- o Insoluble floating substances in water.
- o Insoluble sinking substances in water.
- o Soluble substances in water.

The criteria are based on a method's (1) degree of risk to response personnel, (2) ability to limit damage to public health and to the environment, (3) secondary effects of use on the environment and effects on future cleanup, (4) availability of equipment, materials and, if necessary, trained personnel, (5) speed of application, and (6) usefulness in different weather and topographic conditions. The criteria used to evaluate emergency spill countermeasures for releases on land are described in more detail in Table 1. Similar criteria were adopted accordingly to accommodate the other three spill scenarios.

TABLE 1. CRITERIA USED TO EVALUATE EMERGENCY CONTROL METHODS FOR SPILLS ON LAND

PERFORMANCE CRITERIA

I. Ability to Limit Damage to Environment and Public Health

A. Promotes stabilization of substances on surface. Stabilization may involve a containment technique which controls spreading, prevents entrance to public water sources and sewers and localizes the substance so it can be cleaned up. Stabilization could also be accomplished by a non-containment technique which may dilute or alter the nature of the substance.

B. Promotes stabilization of substance below the surface by preventing penetration into the ground, thereby avoiding entrance into ground water.

C. Promotes stabilization of substance in the atmosphere by inhibiting volatilization.

II. Effect of Use

A. Will not produce negative secondary aesthetic effects on the environment (e.g., unsightly residuals) or negative impacts, immediate or long term, on flora or fauna.

B. Will not cause repercussions that intensify cleanup efforts. Is capable of being removed after stabilization. Does not significantly increase volume of waste material.

PRACTICALITY CRITERIA

III. Degree of Risk to Response Personnel

A. Safe to employ by response personnel. Does not require response personnel to be immediately close to spill. Does not create additional hazardous conditions. (Dangers from the chemical itself are not considered, only the safety involved in the deployment and use of the method).

IV. Availability of Required Equipment, Materials, and, Where Necessary, Trained Personnel

A. Equipment (including improvised systems) and materials are readily available 95% of the time, considering: (1) the need for trained personnel to use the equipment and/or materials, and (2) the reliability and repairability of equipment.

V. Speed of Application

A. Time required for stabilization of a 10-500 gallon spill is generally 1/2 hour. (Assumptions: effort involves 3-5 people and the time limitation does not involve gathering of equipment, materials, and trained personnel, if necessary.)

VI. Usefulness in Different Weather and Topographic Conditions

A. Not affected by wind, precipitation, and/or air temperature. Not affected by topography, i.e., slope of land, permeability of soil, and hardness of ground.

Although an actual spill incident will always involve a unique set of variables, a hypothetical situation was devised to create a uniform comparative measure for the evaluation. Certain assumptions were made:

- o The substance has the potential to spread on the surface, to penetrate the ground, to disperse in water, and to volatilize.
- o The substance is not on fire when response personnel arrive.
- o The substance is not so acutely toxic to response personnel that it eliminates all possible stabilization procedures.
- o The spill volume is between 10 and 500 gallons.
- o Response effort involves 3 to 5 people.

Results

Using the criteria described above, emergency spill countermeasures were evaluated on the basis of all available information.

Separate consideration was given to both performance (Criteria I, II) and practicality (Criteria III, IV, V, VI). Candidate methods were then classified into three general categories:

A. Recommended methods

B. Methods recommended in special cases

C. Generally unsuitable methods

The categories and their respective methods are presented in Table 2. Methods in Category A met most or all of the criteria and were judged high in both performance and practicality. Methods in Category B were judged high in

TABLE 2. METHODS EVALUATED FOR EMERGENCY CONTROL

	Spills on Land	Insoluble Floaters in Water	Insoluble Sinkers in Water	Soluble Substances in water
ecommended ethods	Foams, (AFFF, protein, fluoroprotein, alcohol or surfactants). Synthetic sorbents (e.g., polypropylene, polythylene). Natural sorbents (e.g., vermiculite, gypsum, sawdust, kitty litter, bentonite). Commercial protective covers. Certain neutralizers (soda ash, limestone, dolomite, sodium bicarbonate, commercial acid and caustic neutralizing agents specifically designed for the purpose). Excavation. Dike (using earthen or improvised materials). Dike (using commercial products). Lining (bentonite or plastic, if compatible with hazardous substance). Pumping Water spray or fog with containment.	Foams (e.g., AFFF, protein, fluoroprotein, alcohol, surfactants). Commercial mechanical booms. Neutralization (soda ash, limestone, dolomite, sodium bicarbonate and commercial acid and caustic neutralizing agents specifically designed for the purpose. Natural sorbents (e.g., vermiculite, sawdust). Synthetic sorbent pads, mats (e.g., polypropylene, polyethylene). Underflow barriers. Dikes (with earthen, improvised, or commercially available materials) to divert flow of water. Filter fences.	Pumping. Overflow barriers. Excavations. Dikes to divert flow (with earthen, improvised, or commercially available materials). Filter fences.	Foams (e.g., AFFF, protein, fluoroprotein, alcohol, surfactants). Certain neutralizers (limestone, dolomite, soda ash, sodium bicarbonate, commercial acid and caustic neutralizing agents specifically designed for the purpose.
ethod ecommended n Special ases	Gelation. Dilution with containment.	Spill herding using streams of water.	None	Dilution with containment.
enerally nsuitable ethods	In-situ burial. Soil surface sealants. Foamed concrete dikes. Initiation of burning. Cyrogens.	Skimming Pneumatic barriers Cryogens Burning Sorbent-carbon	Burial Dredging Sorbent-carbon	Precipitation and chelation. Sorbent-carbon.

either performance or practicality, but not both. Although methods in Category B are generally more limited in overall usefulness than those in Category A, they may be appropriate in a specific spill situation. For example, a first responder may recognize that because of immediate safety considerations, time is not available for a high performance method (e.g., pumping) and therefore a more immediately practical method (e.g., dilution with containment) would better apply. It should be noted that combinations of emergency countermeasures, such as diking with pumping and excavation, can be employed by emergency response personnel as conditions warrant. Methods in Category C did not meet most criteria and were not judged high in either performance or practicality. Methods in both Categories A and B, but not those in Category C, have been incorporated into spill response charts designed for groupings of CERCLA hazardous substances based on physico-chemical properties and hazard potentials.

Development of response charts

The CERCLA hazardous substances were grouped into class/subclass categories based on physical/chemical properties that determine their mobility in the environment and the specific hazardous conditions created in the event of a spill. The characteristics and properties used to classify the CERCLA hazardous substances are the "class" properties of reactivity, solubility, density and volatility that predetermine a substance's immediate disposition upon release into the environs and the "subclass" properties of toxicity, flammability/combustibility, persistence, and corrosivity that predetermine a released substance's potential impact on life, property and the environment. Class and subclass designations are listed in Table 3.

Approximately 50 subclass-specific Emergency Response Charts which present safety and emergency environmental response information have been

TABLE 3. CERCLA HAZARDOUS SUBSTANCES CATEGORIZATION

Class	Subclass
I. Dangerously reactive with water, volatile.	A. Highly toxic, persistent, non-corrosive.
II. Dangerously reactive with water, non-volatile.	B. Highly toxic, persistent, corrosive.
III. Soluble, volatile.	C. Highly toxic, non-persistent, non-corrosive.
IV. Soluble, non-volatile.	D. Highly toxic, non-persistent, corrosive.
V. Insoluble, volatile, floater.	E. Toxic, persistent, non-corrosive.
VI. Insoluble, volatile, sinker.	F. Toxic, persistent, corrosive.
VII. Insoluble, non-volatile, sinker.	G. Toxic, non-persistent, non-corrosive.
VIII. Insoluble, non-volatile, floater.	H. Toxic, non-persistent, corrosive.
IX. Gases	I. Highly toxic, persistent, combustible, non-corrosive.
	J. Highly toxic, persistent, combustible, corrosive.
	K. Highly toxic, non-persistent, combustible, non-corrosive.
	L. Highly toxic, non-persistent, combustible, corrosive.
	M. Toxic, persistent, combustible, non-corrosive.
	N. Toxic, persistent, combustible, corrosive.
	O. Toxic, non-persistent, combustible, non-corrosive.
	P. Toxic, non-persistent, combustible, corrosive.

developed for almost 500 CERCLA substances. The generalized safety precautions and emergency response techniques listed on each chart are based on common physical/chemical and environmental hazard characteristics of chemicals in the respective subclass. Some charts pertain to more than one subclass of chemicals because similar responses are involved. An example of a response chart is given in Figure 1. Generalized physical/ chemical and environmental hazard properties are listed for the subclass. For subclasses with ten chemicals or fewer, all chemicals are listed; for those with more than ten, only selected representative examples are given.

Each chart is then divided into two sections. Section A describes general safety hazards and recommends a safety equipment level and protection for response personnel. Section B highlights significant potential environmental hazards along with requisite precautions, and describes prioritized effective stabilization techniques for spills on land and in water.

EMERGENCY RESPONSE PROCEDURES

The following steps should be taken during the emergency phase of a spill response so that effective stabilization of the spill can be achieved with minimal risk to the first responder and the environment. Once the spill report information identifying the hazardous substance has been received, the following steps should be taken by the first responders:

1. Determine Safety Hazards (Use Response Charts)
2. Determine Severity of Spill
3. Apply Precautionary Measures
4. Stabilize Release Situation
    a Stop Release
    b Control Release (Use Response Charts)

FIGURE 1. EMERGENCY RESPONSE CHART EXAMPLE

Class/Subclass
I/B,D

Chart No. 1

Properties: Dangerously reactive with water, volatile, highly toxic, corrosive, flammable or may produce flammable and poisonous vapors especially in the presence of moisture or metals.

Chemicals: Arsenic Trichloride, Phosphorous Oxychloride

SECTION A — Safety Hazards

- Poisonous if inhaled, swallowed, or absorbed through skin.
- Liquid and vapors highly irritating to skin and eyes.

Level of Protection (See Page 37) - A

SECTION B

Spill Stabilization Methods

DO NOT USE WATER OR FOAM ON MATERIAL. KEEP SPILL AWAY FROM ALL IGNITION SOURCES AND METAL OBJECTS. DO NOT APPROACH SPILL TOO CLOSELY.

METHOD (See Page 143)	COMMENTS
LAND	
1. Absorb and contain with commercial sorbents	Use sorbent booms, pillows, mats, or pads to block sewers and entrances to waterways. Use sorbent downgrade from spill to stop flow.
2. Use commercial protective covers	Use over manholes, storm drains, and vents in spill vicinity or in path of flow.
3. Dig an excavation if a natural containment area is not present	(Difficult if ground is hard. May be ineffective on very porous substrates such as sand.)
4. Build a dike using commercial products, if available, or earthen or improvised materials	Use to divert into a containment area. Use to divert away from sewers and other danger areas. Use to contain spill. (Hard ground may prevent using an earthen dike. Polyurethane dikes may be ineffective on cold and wet surfaces.) DO NOT USE ANY METAL OBJECTS IN IMPROVISED DIKES.
5. Cover containment area with a tarp or plastic sheet or	Especially useful on windy days to prevent dispersion.
6. Apply universal gelling agent	Place over and around spill. Most effective for small spills.
7. Neutralize with limestone, sodium bicarbonate, soda ash, or a commercial acid-neutralizing agent	Most effective when spill is contained. (Limestone may be ineffective because of slow reaction time). HANDLE SODA ASH WITH CARE.
WATER	
1. Neutralize with limestone, sodium bicarbonate, soda ash, or a commercial acid-neutralizing agent	Most effective when spill is contained and when spill is considerably larger than volume of water it interacts with. (Limestone may be ineffective because of slow reaction time.) HANDLE SODA ASH WITH CARE.

5. Assess Effectiveness of Response

6. Terminate Emergency Response

Safety hazards identification

Using Response Chart Section A (see Figure 1), general safety hazards associated with a particular CERCLA class/subclass can be identifed. The safety of the public and personnel responding to a hazardous material spill is of the utmost importance. After securing the public safety, the next concern of response personnel should be to define the hazards involved as quickly, safely, and completely as possible. Once the hazardous chemical is identified, the spill response personnel should follow proper safety procedures and utilize protective equipment appropriate for use in and around a spill of that specific hazardous substance. Wear proper breathing apparatus and protective gear if it is necessary to approach the hazardous substance spill. Generally, backup support should be present before entering a contaminated area. Care should be exercised around torn and twisted structural materials, resulting from wrecks of transport vehicles or explosions at installations, to avoid cutting or tearing protective clothing or snagging breathing apparatus on such debris. Furthermore, until the hazards can be better defined, it is best to approach a spill from upwind assuming worst-case ambient concentration of the substance.

Onsite assessment of spill severity

Once the spilled hazardous substance has been identified, and properties determined, the spill's severity should be assessed. The objective of the onsite assessment is to determine the relative seriousness of the situation and the safety hazard to the public and the workers, provide input for

selection of precautionary measures and release stoppage and control techniques, and define the necessary resources (i.e., manpower and equipment) for stabilization.

Three groups of variables contribute to the seriousness of a spill. Basically, these variables include (1) characteristics peculiar to the spilled substance, (2) spill site topography and location and (3) local weather conditions. Table 4 presents 13 variables to be considered when a spill's severity is being assessed. A combination of these conditions will be encountered during most spills.

Class—The hazardous substance class determines two important spill behavior patterns: (1) reactivity with water and (2) dispersion potential. Since water in some form might be present at a spill site, the class designation determines the potential for reaction with water to release toxic, corrosive, or flammable vapors and fumes. Dispersion by volatilization into the air or transport of soluble components in water columns is determined by the substance's evaporation rate, solubility in water and density.

Subclass—The hazardous substance subclass determines the substance's hazard potential with greater emphasis on toxicity and flammability than on persistency and corrosivity characteristics.

Volume—The volume of spilled material directly influences: (1) the spill dispersion range, (2) the extent of possible exposure, and (3) the resources needed to stabilize the spill.

Physical State—The physical state of a substance largely determines its limit of dispersion and its ease of stabilization. The air and ground temperature, in conjunction with the physical properties of the chemical, will determine a substance's physical state. When a solid is released onto land, it will generally be contained within a small area, whereas a free flowing

TABLE 4. GENERAL SPILL SEVERITY CONDITIONS

Spill Properties	Low Severity	Moderate Severity	High Severity
o Class	VII, VIII	III, IV, V, VI	I, II, IX
o Subclass	G,H,O,P	C,D,E,F,K,L,M,N	A,B,I,J
o Volume	500 gallons	500-5,000 gallons	5,000 gallons
o Physical State	Solid	Semi-solid	Free flowing, liquid, gases
o Fire	No fire present	No fire present but combustible conditions	Fire present
Topography			
o Natural Containment	Present and sufficient	Present but insufficient	Not present
o Ground surface permeability	Low (concrete asphalt, clay)	Medium (loose soil fine sand)	High (coarse sand, gravel)
o Distance to sensitive areas	500 feet	100-500 feet	Within 100 feet, or in waterway
o Ground Slope	Flat	Moderate (<10°)	Steep (>20°)
Weather			
o Air Temperature	Cold	Mild	Hot
o Precipitation	None	Light	Heavy
o Wind Speed	Calm	Light	High, gusty
o Wind direction	Away from sensitive areas	—	Towards sensitive areas

liquid or gas will disperse according to topography and weather conditions.

Fire—If a combustible or flammable substance is ignited upon release, the severity of a spill greatly increases. New hazards such as spreading of fire, smoke, and toxic fumes and explosions will become the primary safety concerns for first responders.

Containment—In some spill situations, natural or man-made containment barriers may be present. This is especially true for in-plant storage and loading operations at industrial facilities. Other spill sites may have natural depressions, ditches, and dry stream beds which would greatly facilitate containment and stabilization efforts.

Ground Surface Permeability—The permeability or porosity of the underlying ground surface will determine the extent of downward movement of the spilled substance. This, in turn, dictates the degree of control and necessary eventual removal of contaminated material. The extent of downward movement can range from negligible on a concrete pad to several feet through sand and gravel within a brief period following a moderate-size spill.

Distance to Sensitive Areas—Since a primary objective of a spill response is to limit both the spread and the exposure of the public to hazards, the location, distance and pathways to sensitive areas such as waterways, sewers, and public areas, must be determined. Once these are known, steps can be taken to eliminate or restrict the flow or spread of a spilled substance along those routes that could jeopardize sensitive areas.

Ground Slope—For spills on land, the slope and drainage of the spill site will affect the dispersion of spilled liquids and soluble solids. A relatively flat ground surface can accommodate a containment barrier easier than a sloped surface. Also, in case of heavy rainfall, the runoff flows generated by sloped ground can overflow minimal containment structures.

Air Temperature--Extreme temperatures can have either a positive or a negative effect on control of a spilled substance. Cold temperatures lower a substance's evaporation rate and increase a liquid's viscosity. Freezing temperatures will delay downward movement of liquids on frozen surfaces. On the other hand, high temperatures increase the rate of evaporation and decrease a liquid's viscosity.

Precipitation--Rainfall can have a positive influence on a spill by reducing hazards via diluting concentrated substances which are soluble and non-reactive with water. However, this advantage may be outweighed by the greater increase in spill volume and subsequent containment requirements arising from such dilution. Other negative impacts could be chemical reaction with water, whether from rain or snow melt.

Wind Speed--Usually, wind speed is important when fire is present and/or if flammable gases, toxic fumes, or smoke threatens public areas. Wind speed also determines the effectiveness of various stabilization techniques such as foams and water mists. Usually, when winds are gusty, fire and/or fumes can be spread over a large area making precise evacuation distance calculations difficult and application of foams to control vapors ineffective. Light winds can actually help a spill response in dispersing fumes, thus reducing worker exposure.

Wind Direction--Wind direction is of importance when fire, toxic smoke, flammable gases, or fumes are present and sensitive areas are downwind of the spill site. Wind direction also largely determines necessary areas of evacuation.

Precautionary response measures

Precautionary measures are initial actions taken during an emergency response to minimize the threat to worker and public health and safety. Five

general precautionary measures that need to be considered and implemented, if required, after the spill severity has been determined are isolation of the spill area, elimination of ignition sources, restriction of water use, prevention of reactions between incompatible substances, and control of fire at the spill site, if applicable.

Isolation of Spill Area— All spill sites need to be secured to eliminate access by unauthorized persons. Even if the spill has already been contained by natural barriers, exposure of persons to volatile emissions, which may be toxic or flammable, must be minimized. To secure the spill site the response team should (1) seek assistance of local police for traffic and crowd control, (2) restrict unauthorized entry into spill site, (3) construct physical barriers such as barricades and fencing, (4) post "No Admittance" signs at entrances, (5) assign personnel responsible for site security, and (6) inform the public on radio/or television to avoid area, if warranted. In extreme situations, temporary evacuation should be considered. The final decision of when and where to evacuate persons is critical, and many site-specific considerations are involved[2]. The decision requires the support of response personnel and local officials. If evacuation is to be performed, responsible parties should (1) implement contingency plan if available, (2) determine movement of plume from spill site, (3) identify general threatened areas and sensitive components, (4) seek assistance of local police and health, fire, utility, and industry personnel, (5) notify and warn those persons affected in

2. Several references for calculation of evacuation distances include: (1) the EPA Flammable Hazardous Substances Emergency Response Handbook: Control and Safety Procedures, (2) the USCG CHRIS Manual, and (3) the DOT Emergency Response Guidebook.

evacuation areas, (6) provide transportation and support personnel for relocation assistance, (7) survey evacuated areas for complete evacuation, (8) monitor toxic and/or flammable levels downwind of spill within evacuation area, and (9) determine when safe levels are obtained and evacuation order can be rescinded.

Elimination of Ignition Sources— Because some substances may be flammable and/or combustible and can create an ignitible mixture when released, measures need to be taken to eliminate all possible sources of ignition. Otherwise, explosions and/or fires can occur which drastically increase the safety hazards associated with the spill. Elimination of ignition sources is generally possible by strict site security and controlled site access. However, in situations where flammable plumes are carried sizable distances away from the spill site, elimination of ignition sources over large areas as well as evacuation of people from large areas may be necessary.

The most severe fire and/or explosion hazards exist when flammable substances flow into enclosed areas such as sewers, basements, and underground vaults. All sources of ignition must be eliminated, and ventilation by forced air must be considered to lower the probability of an explosion and/or fire until readings below the lower explosive limit (LEL) are maintained.

Examples of common sources of ignition that should be removed from the spill site are internal combustion engines, cigarette, cigar and pipe smoking, lighters and matches, flares, stoves, hot metal surfaces, impact sparks, small electric motors, cameras with flash, flashlights, and cutting torches.

Restriction of Water Use— When spills reach waterways or sewers, precautionary measures may need to be taken to restrict the routine use of water sources. Such uses may include, private and public drinking use, farm

and agricultural use, industrial process and/or cooling use, recreational use (e.g., boating, fishing, swimming), and waste disposal use (e.g., sanitary sewer).

To restrict water use, responsible parties may need to notify local water and health authorities, state water control offices, and private water users; limit downstream intake, if possible; prevent livestock from reaching waterway; protect drinking water intakes by physical methods; supply alternative sources of drinking water, if required; limit use of water for household and business sanitary disposal, if spill enters sanitary system; and notify local wastewater treatment plant, if spill enters sanitary system.

Prevention of Deleterious Reactions— In cases where a spilled substance may come into contact with (1) other spilled chemicals, (2) stored chemicals, (3) water, or (4) wood, metals, and other construction materials, precautionary measures should be taken to minimize reactions which may cause serious safety hazards. The most common incompatible mixtures are presented in the Emergency Response Charts, as appropriate (See Figure 1). Potentially incompatible materials should be removed from the flow path of a spilled hazardous substance. Once emergency control measures described in the response charts are implemented, control equipment and chemicals must be judiciously selected for compatibility with the released substance.

Control of Fire— If a hazardous substance is on fire, or if fire is involved in the emergency situation, two precautionary measures are available: controlled burning or extinguishment. The decision of whether to allow a fire to continue burning or to extinguish it is a very difficult one but is usually based on safety. Generally, fires should only be extinguished if they can be completely extinguished and all possibility of re-ignition can be eliminated. Several factors influence the decision as shown in Table 5.

TABLE 5. GENERAL CRITERIA FOR "BURN/NO BURN" DECISIONS

Criteria	Allow to Burn	Extinguish
o Spill location	Isolated away from public and buildings	Close proximity
o Availability of safety equipment	Limited	Self-contained breathing and protective clothing
o Population density	Low, evacuated	High, not evacuated
o Presence of other combustible materials	None present	Hazardous materials; petroleum or natural gas transmission or storage; wooded areas; and other combustible structures
o Substance spilled	High vapor pressure Highly toxic vapors Non-toxic combustion products	Low vapor pressure Low toxic vapors and fumes Hazardous by-product produced from combustion
o Containment status	Complete	Uncontrolled
o Release from source	Continuing	Stopped
o Availability of foams, dry chemicals, or powders	Limited	Sufficient
o Wind conditions	Calm	Strong, gusty

Note: Several references for control of fire situations or flammable substances during spills include: (1) the EPA Flammable Hazardous Substances Emergency Response Handbook: Control and Safety Procedures, (2) the NFPA Fire Protection Guide, and (3) the Bureau of Explosives' Emergency Handling of Hazardous Materials in Surface Transportation.

Release stabilization methods

Release Stoppage— The damage from potentially serious spills can be greatly lessened by prompt action to stop or reduce the release of a hazardous substance. However, since controlling the release at the source can be extremely dangerous, safety concerns greatly reduce its availability to spill responders. Before attempting to stop a release, initial responders must first determine whether an attempt should be made and, if so, what the best method(s) for accomplishing the task would be.

Although actual spill site and source conditions dictate the answers to those questions to a great extent, several general considerations are presented in Table 6 to assist in determining whether to attempt stopping a release from a source. If most of the listed considerations suggest that an attempt to stop the release should be made, selection of the best method(s) is critical for success. In no instance should an attempt be made to stop the release without proper safety equipment. Methods typically suggested for stopping releases or leaks consist of (1) patching or plugging, (2) changing container position, (3) valve closing, and (4) pumping of the source.

Release Control— Along with identifying hazards and precautions that may pertain to all or some of the hazardous substances in the subclass, Section B of the Emergency Response Chart (See Figure 1) prioritizes and describes effective stabilization techniques for spills on land and in water. In most spill situations no one method will mitigate all hazards, such as dispersion into the air, permeation into the soil, uncontrolled spreading, and entrance into the water sources. To the maximum extent possible, stabilization techniques are listed in a logical sequence designed to efficiently and effectively mitigate all spill hazards. However, not all methods apply to all situations, because of variations in weather conditions(rain, wind, and air

TABLE 6. GENERAL CONSIDERATIONS FOR STOPPING RELEASES

Criteria	Attempt	No Attempt
o Availability of safety equipment*	Sufficient	None
o Nature of discharge	Open valve or pump failure	Rupture or explosion
o Substance (class/subclass)	VII, VIII E,G,M,O	I, II, IX B,D,J,L
o Volume spilled/volume remaining ratio	Low	High
o Containment of spillage	None	Present and sufficient
o Rate of discharge	Slow, dripping	Fast, streaming
o Size of hole or rupture	Small	Large
o Potential of fire	No potential	Already existing
o Relative difficulty in stopping discharge	Easy	Great

* In no instance should an attempt be made to stop a discharge without the proper protective clothing and safety equipment.

temperature), availability of equipment and personnel, volume of spill, time contraints, worker and public safety, and the ability of various methods to handle liquid versus solid spills. Limitations are listed with methods to aid the first responder in judging applicability. Where there are two or more effective techniques to handle the same spill hazard, they are listed in order of effectiveness.

Neutralization and dilution are often listed last in the sequence of methods. Generally, neutralization is not necessary if the other options are successful. Dilution should be implemented only when all other methods have been eliminated from consideration or when extreme safety hazards prevail and then only with proper containment. Also, the charts do not apply to very small spills on land that do not require containment. Small dry spills can generally be shoveled into a dry container and covered; small liquid spills can be absorbed with natural or synthetic sorbents, shoveled into a dry container, and covered.

Assessment of spill response

An ongoing assessment of spill response efforts during the emergency phase is necessary to (1) identify ineffective, inappropriate and/or unsafe release stoppage or stabilization techniques, (2) modify and/or replace those techniques, and (3) plan for cleanup efforts and/or final removal. The major factors that can affect an ongoing response include change in weather conditions (e.g., rain), appearance of new safety hazards (e.g., fire), malfunction of equipment (e.g., pump failure), and shift in priorities due to public concerns.

The effectiveness of an emergency spill response depends on a number of factors, including: (1) availability of trained response personnel, (2) response personnel protection, (3) public protection, (4) stabilization, and

(5) notifications. Table 7 assesses overall spill response effectiveness. Ineffective or low-rated responses should be modified by one or more of such activities as enlisting the aid of more qualified spill response personnel, increasing manpower resources, obtaining additional or improved safety and/or stabilization equipment, and using different stabilization methods.

Emergency response termination

The emergency response phase is not completed until the spill has been controlled to the extent that the threat of further damage to life, property and the environment has been removed. Three criteria should ideally be met before the emergency is deemed under control and subsequent removal, cleanup, disposal, and recovery operations are begun:

- The potential for additional acute exposure of the workers and the public to hazardous substances has been eliminated or reduced to an acceptable level.
- All safety hazards such as accidental ignition potential explosion, and dangerous incompatible reactions have been addressed and controlled.
- The potential for further environmental contamination has been eliminated as much as possible.

TABLE 7. SPILL RESPONSE EFFECTIVENESS

Factor	Very Effective	Minimally Effective	Ineffective
Trained Personnel	Readily available	Some	None on site
Personnel Protection	Sufficient	Limited	None
Public Protection	No exposure	Some exposure	High exposure
Spill Stabilization	Absolute, no additional exposure	Incomplete, low-level exposure	No stabilization performed
Source Abatement	Stopped upon arrival	Possible, but no attempt	Not possible and no attempt
Spill Containment	Within smallest area possible	Contained over large area	No containment
Notifications	All applicable contacts	Some contacts	No contacts

DISCLAIMER

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